

Applicant: Dieter JUNGER et al
Docket No. R.306813
Preliminary Amdt.

AMENDMENTS TO THE SPECIFICATION:

Page 1, please add the following new paragraphs before paragraph [0001]:

[0000.2] CROSS-REFERENCE TO RELATED APPLICATION

[0000.4] This application is a 35 USC 371 application of PCT/EP 2005/050201 filed on January 19, 2005.

[0000.6] BACKGROUND OF THE INVENTION

Please replace paragraph [0001] with the following amended paragraph:

[0001] ~~Prior Art~~ **Field of the Invention**

Please replace paragraph [0002] with the following amended paragraph:

[0002] The invention is ~~based on a~~ directed to an improved fuel injection valve for internal combustion engines, ~~of the kind known from German Published Patent Application DE 102 05 970 A1. An outer valve needle and an inner valve needle are disposed in the fuel injection valve and are both longitudinally displaceable; the inner valve needle is disposed in the outer valve needle. The valve needles, with a correspondingly embodied sealing face, cooperate with a valve seat and in the process each control the opening of at least one injection opening. Both on the outer valve needle and on the inner valve needle a respective sealing face is embodied, which upon subjection to fuel pressure exerts an opening force, oriented away from the valve seat, on the respective valve needle. In the housing, a control chamber is furthermore embodied, by the pressure of which a closing force oriented counter to the opening force is exerted on the outer valve needle and the inner valve needle. The control chamber can be filled with fuel under pressure, and the pressure in the control chamber can be regulated via a valve.~~

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Please add the following new paragraph after paragraph [0002]:

[0002.5] German Published Patent Application DE 102 05 970 A1 discloses a fuel injection valve having an outer valve needle and an inner valve needle which are both longitudinally displaceable; the inner valve needle is disposed in the outer valve needle. The valve needles, with a correspondingly embodied sealing face, cooperate with a valve seat and in the process each control the opening of at least one injection opening. Both on the outer valve needle and on the inner valve needle a respective sealing face is embodied, which upon subjection to fuel pressure exerts an opening force, oriented away from the valve seat, on the respective valve needle. In the housing, a control chamber is furthermore embodied, by the pressure of which a closing force oriented counter to the opening force is exerted on the outer valve needle and the inner valve needle. The control chamber can be filled with fuel under pressure, and the pressure in the control chamber can be regulated via a valve.

Page 2, please replace paragraph [0005] with the following amended paragraph:

[0005] ~~Advantages of the Invention~~ **SUMMARY OF THE INVENTION**

Please replace paragraph [0006] with the following amended paragraph:

[0006] The fuel injection valve according to the invention[[,]] ~~having the definitive characteristics of claim 1~~, has the advantage over the prior art that the inner valve needle can open before the outer valve needle, which permits greater freedom of design in shaping the course of injection. Moreover, **a single control chamber acting on both valve needles** the ~~control chamber with only one control chamber~~ is possible. To that end, the inner valve needle and the outer valve needle are always acted upon by the fuel of the inflow chamber in

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such a way that the result is an opening force on the valve needles that is oriented counter to the closing force. Since a different opening pressure of the outer valve needle and the inner valve needle can be achieved via a suitable design of the respective faces, subjected to pressure, on the valve needles, it is possible by way of regulating the pressure in the control chamber for the inner valve needle to open before the outer valve needle.

Page 3, please replace paragraph [0007] with the following amended paragraph:

[0007] Advantageous refinements of the subject of the invention are possible ~~by means of the dependent claims~~. In a first advantageous feature, the intermediate chamber between the outer valve needle and the inner valve needle always communicates hydraulically with the inflow chamber. The inner pressure face is subjected to the pressure of the intermediate chamber, so that the desired opening force on the inner valve needle results. Because of the pressurized connection of the intermediate chamber with the inflow chamber, a deformation of the outer valve needle caused by pressure differences on the outside and inside of the outer valve needle is furthermore avoided, so that the friction between the outer valve needle and the inner valve needle always remains slight, and no seizing or excessive friction between these two valve needles can occur. Advantageously, this communication is established via a connecting bore which extends substantially radially in the outer valve needle, and of which preferably a plurality are distributed over the circumference of the outer valve needle.

Please replace paragraph [0008] with the following amended paragraph:

[0008] In a further advantageous feature of the subject of the invention, a shoulder, opposite which is the inner pressure shoulder face of the inner valve needle, is embodied on the inside

of the outer valve needle. The axial spacing of the shoulder from the inner pressure shoulder face is dimensioned such that upon contact of the inner valve needle and the outer valve needle with the valve seat, the inner pressure shoulder remains spaced apart from the shoulder. As a result, an unthrottled inflow of fuel, which is introduced into the intermediate chamber above the shoulder, to the inner injection openings is made possible. It is especially advantageous if the opening stroke of the inner valve needle and the opening stroke of the outer valve needle are adapted to one another such that the valve needles in the opening position are positioned relative to one another such that the shoulder [[of]] on the outer valve needle continues to have an axial spacing from the inner pressure shoulder face. As a result, an unhindered, unthrottled inflow of fuel to all the injection openings is assured.

Alternatively, it may also be provided that the stroke stop of the outer valve needle is formed by the contact of the shoulder with the inner pressure shoulder face. As a result, when the valve needles are open, a pressure drop in the intermediate chamber occurs, which presses the outer valve needle against the inner valve needle as a result of the compressive forces, so that the outer valve needle is prevented from leading ahead of the inner valve needle in the closing motion. A synchronous closure of the inner valve needle and outer valve needle is thus assured.

Page 4, please replace paragraph [0009] with the following amended paragraph:

[0009] In a further advantageous feature, the axial spacing of the shoulder from the inner pressure face is dimensioned such that this spacing when the valve needles are open is shorter than the opening stroke of the inner valve needle. As a result, the inner valve needle in its

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closing motion carries the outer valve needle along with it and thus forces it in the direction of the valve seat. Upon the approach of the outer valve needle to the valve seat, severe throttling of the fuel stream to the outer injection openings occurs, so that the hydraulic opening force on the outer valve needle is reduced and presses the outer valve needle back into its closing position in an accelerated way. As a result, the outer valve needle takes its seat on the valve seat only a very short time after the inner valve needle.

Page 5, please replace paragraph [0012] with the following amended paragraph:

[0012] Drawings **BRIEF DESCRIPTION OF THE DRAWINGS**

Please replace paragraph [0013] with the following amended paragraph:

[0013] ~~In the drawings, one~~ One exemplary embodiment of the fuel injection valve of the invention described herein below, with reference to the drawings, in which: is shown.

Please delete paragraphs [0016] and [0017].

Page 6, please replace paragraph [0018] with the following amended paragraph:

[0018] Fig. Figs. 3, 4 and 5 show various opening positions of the valve needles, the view being identical similar to that of Fig. 2;

Please replace paragraph [0019] with the following amended paragraph:

[0019] Fig. 6, in ~~a~~ an identical view similar to Fig. 4, shows an alternatively embodied outer valve needle,

Please delete paragraph [0020].

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Please replace paragraph [0021] with the following amended paragraph:

[0021] [[Fig.]] **Figs. 7 and 8** show a further exemplary embodiment; and

Please replace paragraph [0023] with the following amended paragraph:

[0023] ~~Description of the Exemplary Embodiments~~

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Page 8, please replace paragraph [0026] with the following amended paragraph:

[0026] A control chamber 28, which is filled with fuel and whose pressure can be regulated, is defined by the face end 56 of the inner valve needle 17, the annular-disklike face end 58 [[and]] of the outer valve needle 15, the throttle plate 5, and a sleeve 26, which is disposed on and surrounds the end, remote from the valve seat, of the outer valve needle 15. The control chamber 28 communicates, via an inflow throttle 34 embodied in the throttle plate [[15]] 5, with an inflow conduit 9 by way of which the inflow chamber 12 can be filled with fuel at high pressure. In the throttle plate 5, an outflow throttle 36 is also embodied, by way of which the control chamber 28 can be made to communicate with a fuel tank 42; a low fuel pressure always prevails in the fuel tank 42. In the connecting line from the control chamber 28 to the fuel tank 42, there is a control valve 40, which opens and closes the communication. The control valve 40, in the exemplary embodiment shown, is embodied as a 2/2-way valve.

Page 9, please replace paragraph [0028] with the following amended paragraph:

[0028] A connecting bore 38 is embodied in the outer valve needle 15 and connects the inflow chamber 12, in which a high fuel pressure always prevails, with the intermediate

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chamber 50. Through the connecting bore 38, an inner pressure face 48 of the inner valve needle 17, which face is embodied on the side of the valve seat toward the connecting bore 38 on the inner valve needle 17, is acted upon by the fuel pressure of the inflow chamber 12. The result is a hydraulic force that points away from the valve seat 20 and is oriented counter to the force of the inner closing spring 30. Diametrically opposite the inner pressure face 48, a shoulder 47 is embodied on the inside of the outer valve needle 15; in the **closing spring position** of the outer valve needle 15 and the inner valve needle 17, or in other words when these needles are in contact with the valve seat 20, this shoulder is axially spaced apart from the inner pressure face 48. This spacing is marked h_m in Fig. 2. In the same way, an outer pressure face 49 is embodied on the outer valve needle 15 and is acted upon by the fuel pressure in the inflow chamber 12, as a result of which the outer valve needle 15 experiences an opening force oriented counter to the closing force of the outer closing spring 32. By means of the ground faces 64 on the collar 62, it is assured that the outer pressure face 49 is always subjected to the full fuel pressure.

Page 10, please replace paragraph [0029] with the following amended paragraph:

[0029] The mode of operation of the fuel injection valve is as follows: At the onset of the injection, the control valve 40 is closed, and thus the communication of the control chamber 28 with the fuel tank 42 is interrupted. As a result, via the inflow throttle 34, the same pressure builds up in the control chamber 28 as in the inflow chamber 12; the inflow chamber, because of its communication via the inflow conduit 9, is always kept at a high fuel pressure. Because of the pressure in the control chamber 28, a hydraulic force results on the

face end 56, remote from the valve seat, and the spring shoulder 54 of the inner valve needle 17 and the face end 58 of the outer valve needle 15. As a result of the differential pressure between the hydraulic pressure in the control chamber 28 and the pressure chamber 12 on the one hand and the combustion chamber pressure on the other, which latter pressure partly acts on the inner valve sealing face 19 and the outer valve sealing face 18, in addition to the force of the closing springs 30, 32, the outer valve needle 15 and the inner valve needle 17 are kept in their closing position[[,]] ~~in addition to the force of the closing springs 30, 32~~. To that end, the area of the face ends 56, 58, the valve sealing faces 19, [[23]] 18, and the other faces of the inner valve needle 17 and the outer valve needle 15 that are acted upon by the fuel pressure in the pressure chamber 12, are designed accordingly.

Page 12, please replace paragraph [0032] with the following amended paragraph:

[0032] To terminate the injection, the control valve 40 is closed, so that via the replenishing fuel flowing through the inflow throttle 34, the fuel pressure in the control chamber 28 rises again. The valve needles begin their closing motion, after exceeding ~~the respecting their~~ respective closing pressure in the control chamber 28, and the closing pressure of the outer valve needle 15 is reached earlier than that of the inner valve needle 17. The reason for this is on the one hand that the force of the outer closing spring 32 is greater, and on the other that the hydraulic compressive forces on the outer valve sealing face 18 are less, because of the throttling of the fuel flow from the inflow chamber 12 in the direction of the outer injection openings 22, than the hydraulic compressive forces on the inner valve needle 17. During the closing motion of the outer valve needle 15, the pressure in the control chamber 28 remains at

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least approximately constant, since the fuel inflow via the inflow throttle 34 and the enlargement of the control chamber 28 compensate for one another. As the outer valve needle 15 approaches increasingly closer to the valve seat 20, the throttling at the outer valve sealing face 18 increases, resulting in an accelerated closure of the outer valve needle 15. The position of the outer valve needle 15 and the inner valve needle 17 relative to one another, at which position the outer valve needle 15 has already taken its seat on the valve seat 20 but the inner valve needle 17 is still spaced apart somewhat from the valve seat 20, is in turn shown in Fig. 3.

Page 16, please add the following new paragraph after paragraph [0038]:

[0039] The foregoing relates to a preferred exemplary embodiment of the invention, it being understood that other variants and embodiments thereof are possible within the spirit and scope of the invention, the latter being defined by the appended claims.